NASA-USGS Post-doctoral Fellow Opportunity Proposal 2018

Hyperspectral Data Products for Ecosystem Science and Natural Resource Management

The Challenge: Ecological systems across the Nation are undergoing historically unprecedented changes. Conifer forests are experiencing extreme dieback, coastal regions are suffering more frequent flooding, and persistent drought in the U.S. West and Pacific Islands threatens fish and wildlife. The challenges posed by these changes are compounded by land-use pressure and our reliance on ecosystems for food, water supply, recreation, and other benefits. Our dependence on natural resources and functioning ecosystems makes us increasingly interested in detailed information on the state of our ecosystems and how they are changing. This information can provide early warning of vegetation shifts, aid allocation of water resources, and inform coastal land-use planning. Currently, however, we are limited in our capacity to fully observe and quantify the complexity of ecosystems at scales that are relevant to researchers, managers, and decision makers.

The 2017 Decadal Survey (DS), "Thriving on Our Change Planet: A Decadal Strategy for Earth Observation from Space[1]," summarizes our needs in three key questions:

1. What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space?
2. What are the fluxes (of carbon, water, nutrients, and energy) between ecosystems and the atmosphere, the ocean and the solid Earth, and how and why are they changing?
3. What are the fluxes (of carbon, water, nutrients, and energy) within ecosystems, and how and why are they changing?

To answer these questions, the DS envisions a hyperspectral observing system, the Surface Biology and Geology (SBG) Designated Observable, that will be similar to the Hyperspectral Infrared Imager (HyspIRI) mission concept. SBG will provide global hyperspectral imagery in the visible and shortwave infrared regions of the electromagnetic spectrum, and multi- or hyperspectral imagery in the thermal infrared region. The rich information captured by hyperspectral sensors can characterize and quantify ecosystem parameters to a greater level of precision compared to multispectral data, particularly for biodiversity and species composition, biophysical and biochemical properties, plant stress, nutrients and moisture. Future hyperspectral observing systems such as SBG have the potential to support broad applications. In the era of "Big Data", we are developing the information systems tools and capacity to harness this flow of information. However to take full advantage of these technologies, there is a need to develop hyperspectral remote-sensing products that are robust to within and across year variability, latitudinal gradients and differences in vegetation structure across ecosystems.

[1] "National Academies of Sciences, Engineering, and Medicine. 2018. *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24938.

The Opportunity: In anticipation of the USGS Menlo Park campus move to Moffett Field in 2019, and co-location with the NASA's Ames Research Center in Mountain View, CA, we seek post-doctoral research proposals that can leverage the capabilities of both agencies to develop hyperspectral products for one or more ecosystem parameters, including, but not limited to:

- Biophysical or biochemical parameters (e.g. fraction of absorbed photosynthetically active radiation, nitrogen, lignin).
- Measures of biodiversity.
- Measures of vegetation stress or water content.

Proposed data product(s) should address one of the key DS Ecosystem Change science questions listed above, support the management and maintenance of ecosystems and ecosystem services, and have broad applications for natural resources management. A key desired outcome of this research is expanded insight using novel analytical approaches (from remote sensing or other disciplines) and documentation of methodology for hyperspectral data product development that can be applied to other parameters.

Proposals must address the requirement for consistency. A consistent product is one that can be used in multiple ecosystems and is robust to intra- and inter-annual variability. In the development of a methodology, the applicant may consider tradeoffs in various analysis approaches, such as statistical information extraction methods, machine learning and use of radiative transfer models. The applicant may also consider opportunities for fusion of hyperspectral data with additional high spatial and temporal data to improve the final remote sensing product. The successful applicant will also be able to leverage multi-scale hyperspectral measurements from HyspIRI airborne science campaigns, planned SBG airborne campaigns, high-performance computing, Unmanned Aircraft Systems (UAS), and/or field spectroscopy.

The State of California represents one ideal setting for this opportunity. The state includes the California Floristic Province (CA-FP) and Deserts, with the CA-FP being a biodiversity hotspot that includes a mosaic of diverse ecosystems including but not limited to grassland, wetland, shrubland, oak savannah and conifer forest, and both managed and natural lands. This Mediterranean region experiences temporal and spatial variability in precipitation and water availability; this variable climate combined with high geo- and biodiversity create a unique natural laboratory for evaluating the potential to develop consistent hyperspectral data products. Airborne campaigns using AVIRIS (Airborne Visible/Infrared Imaging Spectrometer) are planned for multiple coastal, inland and montane regions of California, and have been ongoing seasonally since 2013. Data products applied to AVIRIS time series may also be used to assess fluxes within and across ecosystems across both drought and extreme wet years, and before or after fire events, or to assess change in ecosystem structure.

The post-doctoral Fellow will have access to substantial co-located NASA and USGS assets, including the NASA Earth Exchange, USGS spectral libraries, the USGS/NASA UAS Research Center, an ASD spectroradiometer, LI-COR quantum sensors, and Trimble sub-meter GPS and image processing software. The NEX platform provides access to high-performance computer resources co-located with ready to use massive data sets of multi-spectral, hyperspectral and lidar data sets and containerized workflows and other analytical tools. Lab resources include the USGS Menlo Park Stable Isotope Lab capable of analyzing H_20, C, N, O, H, S, Cl, and Br isotopes in a wide variety of natural materials, including organic matter, gases, and minerals. New and existing AVIRIS surface reflectance products from coastal, inland and montane regions of California will be made available (collections extend back to 2013).

Post-doctoral fellows will be located in one of the vibrant epicenters of global science and technology activity.

Carnegie Mellon University's Silicon Valley campus will be across the street. The DoD Defense Innovation Unit is just a few blocks away. Stanford University, globally recognized science and technology companies, and the most innovative new startups are within a few miles drive.

Proposed Duty Station: **Moffett Field, California**

Areas of Ph.D. Applicant: Including but not limited to: Geography, Ecology, Environmental Science or related fields. Candidates holding a Ph.D. in other disciplines but with knowledge and skills relevant to the Research Opportunity may be considered.

Qualifications: Research Physical Scientist, Research Ecologist. (This type of research is performed by those who have backgrounds for the occupations stated above. However, other titles may be applicable depending on the applicant's background, education, and research proposal. The final classification of the position will be made by the Human Resources specialist.)

Research Advisors:

USGS: Kristin Byrd, (650) – 329-4279, kbyrd@usgs.gov

NASA: Rama Nemani, (650) 604-6185, rama.nemani@nasa.gov